Quantifying the Influence of BC on Climate: What are the uncertainties?

Brooke L. Hemming

US EPA/ORD/National Center for Environmental Assessment

Black Carbon Emissions and Climate Change: A Technical Workshop

October 13, 2004

What do we need to know to correctly calculate the forcing effect of BC aerosols on climate?

1. Ambient BC-containing aerosol mass concentrations

2. Total chemical composition of BC-containing aerosols (inorganics and organics)

3. Direct radiative properties of most (if not all) BC-containing aerosol compositions

4. Cloud altering or producing properties of each composition (indirect radiative effects)

A note on terminology:

"Black carbon" really means carbonaceous light-absorbing aerosol components that came into being during a combustion process.*

"Elemental carbon" is a term used to describe one of a few carbonaceous aerosol components measured using a thermal-optical technique.

*Brooke's opinion

Calculating BC Forcing:

1. Ambient BC-containing aerosol mass concentrations

   - Needed as a function of:
     - Time
     - Horizontal dimension
     - Vertical dimension

   - How to deduce these?
     - Measurements: Direct and indirect
     - Emissions estimates plus a means of predicting temporal variability and spatial distribution

Calculating BC Forcing:

2. Total chemical composition of BC-containing aerosols

   - Mineral dust
   - Inorganic salts
     - Deliquescence behavior in the presence of other components
   - Non-light-absorbing organics
     - Hygroscopic vs. hydrophobic
   - BC
     - Hygroscopic (oxidized) vs. hydrophobic (“freshly emitted”)

Calculating BC Forcing:

3. Direct radiative properties of most (if not all) BC-containing aerosol compositions

- Needed as a function of wavelength across the solar and terrestrial spectra
  - Absorption
  - Scattering

- How to deduce these?
  - Direct laboratory measurements (accounting for any mixture effects)
  - Indirect determinations based on remote sensing of ambient aerosols
  - Calculated

Calculating BC Forcing:

4. Cloud altering or producing properties of each composition (indirect radiative effects)

   - Does the aerosol suppress cloud formation?

   - How does inclusion of BC in a cloud drop:
     - Change its radiative properties?
     - Influence its lifetime (closely related to changes in its radiative absorption properties)?

Other Reasons to Pursue These Questions:

Regional Haze Rule

Class 1 areas (national parks) level of visibility at “natural background”

Human health considerations

Carcinogenicity and ability to absorb visible radiation, i.e. PAHs, have something in common

The focus of this workshop:

Identifying the uncertainties in our estimates of BC emissions -- and the research efforts that will be most effective in narrowing those uncertainties

Questions posed to Speakers:

What are the limits in our ability to measure ambient BC?

- What are the available techniques for measuring carbonaceous mass, size, number density, and optical properties of emissions at the source?
- How good are the numbers? (instrumental uncertainties)

What are the limits in our ability to determine the size, chemical composition, number densities, and optical properties of aerosols directly emitted by BC sources?

- What are the available techniques for measuring carbonaceous mass, size, number density, and optical properties of emissions at the source?
- How good are the numbers? (instrumental uncertainties)
- How do the instrumental uncertainties propagate into emissions inventory estimate?
- (How many of the source profiles needed for climate modeling exist? If not, which are needed? To what extent can source profiles be reasonably generalized?)

What are the limits in our ability to predict the mass and properties of BC emissions from individual source types?

- What are the current methods in use for estimating BC emissions?
- What are the uncertainties in the individual factors used for emissions estimates?
- What alternative estimation methods might be developed for improving emissions inventories?

What are the limits in our ability to estimate total emissions of BC-containing aerosols, spatially and temporally?

- How are sources presently allocated spatially within models?
- How are sources presently allocated temporally within models?
- Can this be done better? If so, how?

How do the uncertainties in emissions inventories compare to other inputs into global and regional climate models and to the uncertainties introduced by assumptions/parameterizations in those models?

- At what level of resolution (speciation, spatial, and temporal) and accuracy do BC emissions inventory uncertainties become significantly less important than uncertainties due to other climate model inputs and model formulation?
- If the levels of uncertainty are comparable, then which inputs/assumptions should receive the greatest research effort over the next 5 years?